Energy Storage Characterization and Management:

1. Modeling and validating the Li-ion cells.
2. Control and management of the energy storage.
3. Integrating different storage devices into the power grid including; batteries, fuel cells, ultracapacitors.

More than 10 patents over the last few years. Some of the latest patents include:

1) Flexible Secure Energy Management System (US 9,915,965 B2)
2) Systems and Techniques for Energy Storage Regulation (US 9,735,601 B2)
3) Autonomous Two-Layer Predictive Controller for Bidirectional Inductive Power Transfer in EV application (US 9,987,937 B1)
4) Sequence Hopping Algorithm for Securing Goose Messages (US 9,894,080 B1)
The FIU Smart Grid Testbed is a unique contemporary research facility which was developed as an integrated hardware based AC/DC system. It features an AC utility grid and multiple microgrids. This cutting-edge hardware/software/communication based system includes capabilities for conceptualizing a holistic Cyber-Physical Smart Grid framework. It is composed of multiple layers including; Energy, Communication and Cyber Physical layers. The connected system is a hardware emulation of a realistic electric utility with a number of microgrids that operate in a realistic manner as they do in real life.

The FIU Smart Grid Testbed gives researchers the ability to:

- Develop, integrate and verify new ideas and techniques in smart grid research.
- Capabilities to practically use, test and enhance modern standards.
- Provide a platform for multiple microgrids connections, electric vehicle penetration and resiliency analysis.
- Provide a platform for testing and evaluating cyber physical system development, including cyber security.
- Provide a platform for testing distributed control, optimization studies and multi-agent communication.
- Support transportation electrification and Smart City Research and Energy Cyber Security.
- Involve trainees in the development and building the various test bed components.
- Study Cyber Physical Systems by developing measures for data handling energy flow and real-time control.
- Conduct experiments on EMS for smart grids including alternate and sustainable sources.

Transportation Electrification: Conducts pioneering research on several advanced power converter topologies. Examples include; transformerless power converters built at FIU for different high power applications for vehicles and ship power systems. Our research also dealt with physics based modeling to identify voltage breakdown mechanisms of the power switch. Application notes include;

A Novel Transformerless Bidirectional DC-DC Converter with Wide Conversion Ratios

The setup is implemented using Silicon Carbide (SiC) MOSFETs. This converter has low voltage stress on the semiconductor devices, wide voltage gain range, low number of components and fast dynamic response. It is suitable for energy storage systems, electric vehicles, microgrids and uninterruptible power supply systems. The power rating of this scaled down prototype is 1.6kW. This topology successfully achieves zero voltage switching during turn on and turn off instances. This converter can perform buck and boost operations in both power flow directions.

A New Single-Switch DC-DC Converter with Wide Voltage Gain for Fuel Cell Vehicles

The setup is implemented using Gallium Nitride (GaN) enhancement high electron mobility transistors (E-HEMTs) and SiC diodes. This converter has lower voltage stress on the semiconductor devices and higher voltage gain compared to conventional three-level boost converters. It is suitable for renewable energy systems and fuel cell vehicles. The power rating of this scaled down prototype is 1.2kW and it operates with switching frequency 100kHz. The developed prototype has a peak efficiency 98%.

Electric Machines, Drives and Electromagnetic Signatures

Challenge: Environmental stresses and with machines’ internal stresses, could cause faults in electric machinery. Also for electromagnetic interference and product evaluation for satisfying international standards.

Objective: The development of failure identification (FI) technique based on stray electromagnetic (EM) field for ITSC recognition. The FI routine is fast, online, non-invasive and easy to implement on digital controllers.

Detecting the fault through Electromagnetic Field Signatures:

1. The electromagnetic signature method is the noninvasive/ nondestructive method.
2. Unlike the diagnosis techniques based on current, the loop antenna is more reluctant to saturation than the current transformers.
3. Using the loop antenna as an external transducer to detect the fault makes it independent of the control/driving algorithm of the motor, and thus more reliable.